TF 2370

110 MHz
Spectrum Analyser

OPERATING MANUAL

No. EBS 2370-015

mi

MARCONI INSTRUMENTS

Supplement No. H 54811-002V

SAFETY PRECAUTIONS

- For inclusion in instruction manuals for mains operated equipment -

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, set the equipment supply switch to ON.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Fuses

Note that the supply fuse is connected in series with the brown (live) wire of the supply lead. If the equipment is connected to the supply via a two-pin plug, it will be possible for the fuse to become connected to the neutral side depending upon the orientation of the plug in its socket. In these circumstances certain parts of the instrument could remain at supply potential even after the fuse has ruptured.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g. fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6 A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

Operating Manual
No. EBS 2370-015
for

TF 2370
110 MHz Spectrum Analyser

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MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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Note

Panel markings are shown throughout this manual in capital letters.

Chapter 1

General information

1.1 INTRODUCTION

TF 2370 is a spectrum analyser/tracking signal generator/counter covering the range 30 Hz to 110 MHz in sweep widths varying from 200 Hz to 100 MHz and with resolutions varying from 50 kHz to 5 Hz. The user selects input sensitivity, sweep width, centre frequency and filter resolution and a wired logic programme selects best r.f./i.f. gain ratio, sweep rate and filter bandwidth.

One of the disadvantages of high resolution swept-filter type spectrum analysers is the long sweep times necessary to scan the required frequency band. In TF 2370 the longest sweep time is 100 seconds. To enable the data scanned during this time to be clearly presented and subsequently analysed, a digital store, consisting of a 256 x 512 bit m.o.s. f.e.t. dynamic shift register, records the processed signal from the wide range logarithmic amplifier and displays this stored data at a flicker free 70 Hz rate on a bright 12 x 10 cm camera monitor cathode ray tube. Superimposed on this display is an electronic graticule which may be moved in both vertical and horizontal directions to facilitate accurate measurements. The stored display of a single shot scan can be measured in frequency to counter accuracy by positioning an electronic cursor in the desired position. Additionally the electronic cursor can be used to manually edit or update the stored image or can be used as a meter, thus providing the facilities of a selective level test set.

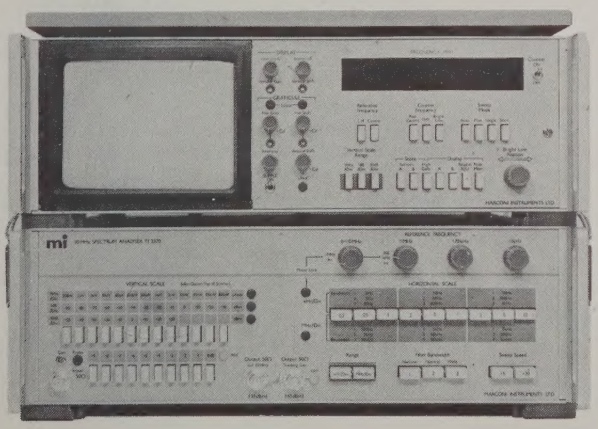

Fig. 1.1 110 MHz Spectrum Analyser TF 2370

1.2 DATA SUMMARY

Amplitude measurement

Input impedance :	50 Ω (BNC type socket).
Input v.s.w.r. :	Less than 1.2 : 1.
Maximum input :	+30 dBm for five minutes (7.1 V r.m.s.). +25 dBm continuous (4 V r.m.s.).
Vertical scale range :	+30 to -159 dBm at 10 dB/div. (1 div. = approx. 1 cm). +30 to -109 dBm at 1 dB/div.
Vertical scale display :	Log : 10 dB/div. for a 100 dB full screen display. 1 dB/div. for a 10 dB full screen display. Linear : 300 mV/div. to 300 nV/div. in a 1, 3, 10 sequence on a 10 division display.
Frequency response : (relative to 10 MHz level)	±1 dB from 100 Hz to 110 MHz. -3 dB at less than 30 Hz.
Gain :	Preset control for adjustment of vertical scale display.
Vertical scale range accuracy :	10 dB steps : ±0.3 dB/10 dB; cumulative error less than ±1.5 dB. 1 dB steps : ±0.1 dB/1 dB; cumulative error less than ±0.3 dB.
Vertical scale display accuracy :	Log : 10 dB/div. Overall law accuracy 0 to -80 dB, ±1 dB; -80 to 100 dB, ±1.5 dB. 1 dB/div. Overall law accuracy ±0.1 dB. Volts/div. linearity : ±1.5% of full-scale range. Quantization error : ±0.25% of full-scale range for 5 Hz to 5 kHz filter bandwidths.
Bandwidth/dispersion switching accuracy :	Maximum error when switching between bandwidths and Hz/div. settings (15 to 25 °C) : Log : ±1 dB, ±1% f.s.d. Linear : ±10%

Average noise level : (between 100 kHz and 110 MHz)	Less than -120 dBm with Counter 'ON'. Less than -130 dBm with 50 Hz filter and Counter 'OFF'.
Spurious responses :	70 dB below a single signal at a level of -40 dBm at input mixer.
Intermodulation display :	-70 dB (two tone test) with signals at -40 dBm at input mixer and 500 Hz apart.
Residual responses :	30 Hz to 20 kHz less than -90 dBm. 20 kHz to 110 MHz less than -100 dBm (measured at input mixer or INPUT socket, whichever is greater).
Amplitude stability :	±0.1 dB/^{O}C.

Calibrator

Output impedance :	50 Ω nominal (BNC type socket).
Frequency :	10 MHz ±20 Hz.
Amplitude :	-10 dBm ±0.3 dB.

Tracking generator output

Enables the transfer characteristic of any network to be measured over a dynamic range of up to 120 dB.

Output impedance :	50 Ω (BNC type socket).
Output v.s.w.r. :	Less than 1.15 : 1.
Frequency :	Within ±2 Hz of the input tuned frequency.
Amplitude :	-10 dBm ±2 dB at 10 MHz.
Frequency response : (relative to 10 MHz level)	±1 dB from 100 Hz to 100 MHz. -3 dB at less than 30 Hz and greater than 110 MHz.

Frequency measurement

Range :	30 Hz to 110 MHz. Four REFERENCE FREQUENCY controls provide frequency cover of 0-110 MHz, ±1 MHz, ±70 kHz and ±1 kHz respectively.

Reference frequency :	The reference frequency may be positioned to the centre or left-hand edge of the graticule display by front panel push button selection. Accuracy : see 'Counter'.
Sweep modes :	Auto : Analyser sweep free runs. Manual : Sweep position determined by the BRIGHT LINE POSITION control which is continuously variable across the display in either direction. In this mode the instrument may be used as a selective level measuring set, a video filter for noise averaging being automatically selected. Single : A single sweep may be initiated by the START control. Start : Sweeps may be terminated at any time by pressing this button. The sweep will recommence when this button is released.
Sweep range :	18 calibrated sweep widths in two bands : 10 MHz/div. to 0.02 MHz/div. and 10 kHz/div. to 0.02 kHz/div. In the kHz/div. mode, the 0-110 MHz and ±1 MHz REFERENCE FREQUENCY controls are phase locked to frequency increments of 1 MHz and 100 kHz respectively.
Sweep range accuracy :	±10% of full-scale ±20 Hz, against electronic graticule. May be set to within ±1% ±20 Hz using internal counter.
Sweep speed :	100 ms to 100 seconds in 1, 2, 5 sequence automatically selected to match the selected SWEEP RANGE and FILTER BANDWIDTH. A x5 and x20 speed up over the optimum is available by press button operation.
Filter bandwidth :	-3 dB filter bandwidths of 5 Hz, 50 Hz, 500 Hz, 5 kHz and 50 kHz. These are automatically selected to give up to three filter bandwidths (NARROW, NORMAL and WIDE) to match the selected sweep range.
Bandwidth accuracy :	±20% of stated 3 dB bandwidth.
Bandwidth selectivity :	60 dB/3 dB filter bandwidth ratio better than 10 : 1.

Resolution and noise sidebands : Using the 5 Hz filter, signals 100 Hz away from a response at 0 dB can be measured to -70 dB.

Long term frequency drift : After 1 hour warm-up (at constant local ambient temperature) :

Range switch in kHz position : 10 Hz/min.; 100 Hz/10 min.

Temperature drift : Range switch in kHz position : 100 Hz/^{o}C.

Counter

A nine digit counter having the following modes of operation enables frequency measurement to be made on any part of the spectral display.

PAST CENTRE : After a sweep the counter memorizes the centre frequency of that sweep.

BRIGHT LINE : Counter measures that part of the stored display identified by the bright line electronic cursor.

DIFF : Counter measures the frequency difference between the above two measurements.

Accuracy : AUTO : ±0.0002%, ±20 Hz, ±1% of full sweep display.

MANUAL : ±0.0002%, ±2 Hz, ±1% of full sweep display.

(After 60 minutes warm-up using the internal frequency standard).

Display

An electronic storage system giving infinite persistence with 100 ms minimum data renewal time provides the following STORE/DISPLAY modes of operation.

HIGH DEFN : Full capacity of electronic store (500 x 200 elements) is used to display the spectrum.

DISPLAY 'A' : Half capacity of electronic store (250 x 200 elements) is used to display the spectrum.

DISPLAY 'B' : Remaining half capacity of electronic store (250 x 200 elements) is used to display the spectrum.

Store :

REFRESH 'A' : In this mode, DISPLAY 'A' is continuously refreshed as in HIGH DEFN, DISPLAY 'B' is permanently stored.

REFRESH 'B' : In this mode, DISPLAY 'B' is continuously refreshed as in HIGH DEFN, DISPLAY 'A' is permanently stored.

READ IN B/U : Display 'Bright-up' indicates the data renewal point on the display.

PEAK MEM : The peak signal level of a spectrum (whose level may be changing) is stored and displayed.

CRT : Camera viewfinder tube with 100 x 130 mm viewing area.

Intensity 'A' : Controls brightness of display on HIGH DEFN and DISPLAY 'A' modes of operation.

Intensity 'B' : Controls brightness of display on DISPLAY 'B' mode of operation.

Vertical gain : Provides preset adjustment of the display amplitude.

Vertical shift : Provides preset adjustment of the display position.

Graticule Nominal 1 cm vertical calibration lines and 1 cm horizontal calibration lines sub-divided to 2 mm, are electronically displayed on the c.r.t.

Horizontal gain : Enables the electronic graticule to be expanded. Cover greater than ±15%. An indicator lamp shows when the control is being operated in the uncalibrated position.

Horizontal shift : Enables the electronic graticule to be positioned over at least ±1.5 major divisions. An indicator lamp shows when the control is being operated in the uncalibrated position.

Vertical shift : Enables the electronic graticule to be positioned over at least 1 major division. An indicator lamp shows when the control is being operated in the uncalibrated position.

Intensity : Controls background brightness of the electronic graticule.

External standard input	Rear BNC socket permits internal 10 MHz standard to be locked to external 1 MHz standard. Green light next to socket glows when adequate signal is applied at the correct frequency to achieve satisfactory lock.
Input impedance :	Approx. 10 kΩ shunted by 100 pF.
Signal level required :	0.25 V to 1.0 V r.m.s.
Frequency :	1 MHz.
Accuracy required :	Better than 1 in 10^7.

Detected output	Rear panel BNC socket provides demodulated output.
Output impedance :	Approx. 600 Ω.
Frequency response :	-3 dB at less than 30 Hz to greater than 20 kHz using 50 kHz filter, relative to level at 1 kHz.
Output level :	0 dBm, ±3 dB, into 600 Ω load for 100% a.m. signal. Maximum undistorted output level occurs if the unmodulated carrier is set to the top of the screen on 1 dB/div. or 40 dB down from the top of the screen on 10 dB/div.

Power requirements

Voltage :	200 to 250 V or 100 to 130 V a.c. at any frequency between 45 and 500 Hz.
Regulation :	±10% on the nominal supply voltage.
Power consumption :	Approximately 150 W (190 VA).

Dimensions and weight	*Height*	*Width*	*Depth*	*Weight*
Display unit (with covers) :	172 mm (6 3/4 in)	440 mm (17 5/16 in)	516 mm (20 5/16 in)	20 kg (44 lb)
RF unit (with covers and clips) :	156 mm (6 1/8 in)	453 mm (17 13/16 in)	516 mm (20 5/16 in)	19.5 kg (43 lb)

1.3 ACCESSORIES

Supplied

Mains Lead, 43123-076.
Connector Assembly (umbilical), 2-off, 43169-005.
Extender Board, 44827-235.
Board Extractor, 41700-048.
Protective Cover, 2-off, 41690-087.
Stay Assembly, 34900-209.
Fuse, quick acting, 250 mA, 23411-004.
Fuse, quick acting, 3.15 A, 23411-008.
Fuse, time lag, 2.0 A, 23411-060.
Fuse (2-off), time lag, 4.0 A, 23411-063.

Optional

Adapter (BNC to phone jack), 43168-016.
RF Fuse Unit, TM 9884, 43281-007.
20 W, 20 dB, 50 Ω Attenuator, 54431-021.
Carrying Case, 2-off, 54112-111.
Rack Mounting Kit, 54127-211

Chapter 2

Operation

2.1 PREPARATION FOR USE

The instrument is constructed in two halves, the upper display unit, and the lower r.f. unit, which are connected at the rear by connector assemblies (43169-005), and are held in position by four toggle latches. The instrument is normally supplied with the units connected. The units, which are adjusted to work together, are identified by identical serial numbers, and may be disconnected for ease of transporting.

Supply voltage adjustment

The voltage selection panel, located on the rear panel of the display unit, is adjusted as follows :

Remove the bar plug, and re-insert in the socket panel so that the arrow points to the correct supply voltage. Normally, the instrument is dispatched with the voltage set to 240 V a.c.

Supply lead

The supply lead is a free cable fitted at one end with a female plug which connects to the instrument. When fitting a suitable supply plug, note that the wires are colour coded as follows :

Earth (ground)	-	Green/yellow
Neutral	-	Blue
Line (phase)	-	Brown

In addition the earth wire has a yellow sleeve with a green earth symbol, and the neutral wire has a sleeve marked with a white 'N'.

Supply fuse

Check that the rear panel supply fuse is correctly rated for the supply in use; 2 A, time lag, for the 200 to 250 V range, 4 A, time lag, for the 100 to 130 V range.

2.2 CONTROLS AND CONNECTORS

Front panel

See Fig. 2.1 at rear of manual.

(1) CATHODE RAY TUBE : 12 x 10 cm camera viewfinder display. The electronic graticule consists of 50 minor divisions and 10 major divisions vertically and 12 major divisions horizontally. The first, middle and last vertical frequency calibration lines are dashed to aid easy identification of the centre frequency point and edges of calibrated scan and also to group the dB scale into easily counted 2 division groups.

(2) VERTICAL SHIFT : The variable GRATICULE SHIFT permits vertical movement of the electronic graticule by ±1.2 major division about the nominal setting. A preset DISPLAY SHIFT control permits the correct calibrated value to be set. This control moves the spectral display behind the graticule and thus cannot be set on a stored picture.

(3) VERTICAL DISPLAY GAIN : Permits the gain of the vertical display to be set so that each graticule division corresponds to 1 dB or 10 dB as appropriate. As with the associated preset SHIFT control this cannot be adjusted on a stored picture.

(4) HORIZONTAL GRATICULE SHIFT : The variable SHIFT control permits horizontal shift of the electronic graticule by at least ±1 division.

The preset control enables the graticule to be set, in the CAL position of the variable control, so that it agrees with the counter readout.

(5) HORIZONTAL GRATICULE GAIN : The variable GAIN control permits horizontal expansion of the electronic graticule by at least ±20% about the first dashed line. The preset control enables the graticule calibration to be set, in the CAL position of the variable control.

(6) DISPLAY 'A', DISPLAY 'B' & GRATICULE INTENSITY : When using the A and B split store mode, these controls operate the individual contrasts of each display. In the HIGH DEFN (13), (14) mode only the DISPLAY 'A' control operates the contrast level. In all cases the GRATICULE control operates the graticule background contrast independently of either display.

(7) SUPPLY ON switch.

(8) REFERENCE FREQUENCY : With the CENTRE button pressed, the swept display will expand about the centre line as the sweep width is narrowed (using buttons (17)) whilst if the LH button is pressed it will expand about the left-hand dashed graticule line. The latter mode is particularly useful if the sweep is required from d.c.

(9) COUNTER FREQUENCY

PAST CENTRE : Every time data is completely renewed on the display the centre frequency is measured and will be displayed on the counter when this button is pressed.

BRIGHT LINE : Whenever the electronic cursor is displayed on the screen (viz. using MANUAL or SINGLE shot modes (11) and the BRIGHT LINE POSITION control (12)) the frequency of any spectral line corresponding to the position of the electronic cursor will be displayed on the counter when this button is pressed.

DIFFERENCE : When this button is used the counter displays the modulus of the difference between the above two frequency values. In all cases the counter resolution is appropriate to the sweep width.

(10) COUNTER READOUT : Nine digit, 9 segment Burrough Panaplex neon display panel. Readout is in MHz with automatic decimal point location.

COUNTER ON/OFF switch : When OFF, prevents counter leakage from interfering with the instrument sensitivity. The signal at the TRACKING GENERATOR OUTPUT (26) is also switched OFF and the adjacent amber light glows.

To measure the frequency of very low level signals, produce a single sweep with the counter OFF. When the sweep is completed, switch the counter ON and measure the frequency with the BRIGHT LINE POSITION control (12).

Note If the system under test is poorly screened, the counter leakage is greater and it becomes essential to switch the counter OFF when it is not in use.

(11) SWEEP MODE

AUTO : In this position, the read-in sweep runs continuously, permitting the counter to record the centre frequency during the retrace of each sweep.

SINGLE : In this mode, a single read-in sweep will be initiated every time the START button is pressed and released. After the completion of a sweep, the centre frequency is recorded during retrace as in AUTO. After retrace, a vertical bright line appears on the screen which is an electronic cursor.

This line may be positioned anywhere on the screen by means of the BRIGHT LINE POSITION 5-turn potentiometer (12) and the frequency corresponding to that point on the screen may be read from the counter display using the BRIGHT LINE button (9).

MANUAL : When this button is pressed, the read-in sweep stops at whatever point has been reached, and the bright line cursor appears. As for SINGLE, the BRIGHT LINE POSITION potentiometer may be used to position this line anywhere on the screen and the counter reads the frequency if switched to the BRIGHT LINE position. However, as the electronic cursor is moved across the screen, the store will record the input signal levels existing at that time at the frequency corresponding to the bright line position. If it is required to selectively edit the stored display, switch between SINGLE (for movement of cursor with no data renewal) and MANUAL as required. A video filter of 1.5 Hz is included in this position for noise averaging. If the rate of movement of the electronic cursor is too fast, some of the original stored picture will be left on the display and the displayed amplitude of some spectral lines will be too small.

START : In the SINGLE sweep mode, press and release this button to initiate a fresh sweep. In both AUTO and SINGLE modes, the pressing of this button will stop the read-in sweep at whatever point is might have reached. When the button is released a complete new sweep will be initiated and then will continue to run if the AUTO mode is being used. If it is desired to keep the picture present when this button has been operated press MANUAL before releasing START button, then switch to SINGLE if no trace editing is required.

(12) BRIGHT LINE POSITION : This 5-turn potentiometer allows the electronic cursor to be positioned anywhere across the display on the manual and SINGLE sweep modes (11).

(13) DISPLAY

A : Press this button to display signals stored in the 'A' part of the store.

B : Press this button to display signals stored in the 'B' part of the store.

HIGH DEFN : Press this button to put the store into a single recording high definition mode.

READ IN B/U : Press this button to add artificial 'persistence' to the display in order to help to identify the data renewal point on slow sweeps.

PEAK MEMORY : If this button is pressed, the store remembers the biggest signal ever to be applied at each point across the screen. This simulates infinite persistence and is useful for displaying oscillator frequency responses and for measuring fine spectral lines using the MANUAL edit mode (11).

(14) STORE : This facility allows selection of a single high definition (500 lines) stored display on HIGH DEFN or two low definition (250 lines) superimposed stored pictures arbitrarily designated A and B.

(15) VERTICAL SCALE RANGE : These three buttons allow selection of 10 dB/division (100 dB display), 1 dB/division (10 dB display) or r.m.s. volts/division. Three blue lights adjacent to the VERTICAL SCALE buttons (21) show the correct scale to read off the absolute signal level.

(16) REFERENCE FREQUENCY : Four five-turn potentiometers permit the centre frequency (or left-hand frequency - see (8)) to be set to any value between d.c. and 110 MHz.

0-110 MHz : When using the MHz/DIV (20) position of the RANGE switch the control adjusts the reference frequency continuously over the band. When using the kHz/DIV (20) position of the RANGE switch the control sets the 1st local oscillator in any of 110 discrete phase locked points corresponding to every MHz of input frequency. For lowest noise and most stable operation. this control should be positioned roughly midway between the two adjacent lock points as indicated by the counter readout. To speed up any tuning in process, select FILTER BANDWIDTH WIDE (19) or use SWEEP SPEED x5 or x20 (18) buttons to shorten counter gate time.

±1 MHz : This control operates in exactly the same manner as the 0-110 MHz control described above except that it covers a 2 MHz range. When using the MHz/DIV (20) position of the RANGE switch the control adjusts the reference frequency continuously and acts as a fine control to the 0-110 MHz control. In the kHz/DIV (20) position it covers the 2 MHz range in 100 kHz phase locked steps and thus complements the 1 MHz settings of the 0-110 MHz control. As before, for the most stable operating point. set the control roughly midway between the two lock points, as seen on the display or counter.

PHASE LOCKING PRECAUTIONS : When switched to the kHz DIV position of the RANGE switch a phase lock tuning system operates on the 0-110 MHz and ±1 MHz REFERENCE FREQUENCY controls.

To avoid malfunction of the system the 0-110 MHz control should be adjusted at a slow or moderate rate If the control is operated too quickly it is possible to break phase lock. If this happens the effect will be obvious from the unstable appearance of the display and the counter readout. Locking can easily be restored by a small movement of the 0-110 MHz control.

±70 kHz, ±1 kHz : Operation of these controls cause continuous variation of the 2nd local oscillator to permit interpolation between the lock points of the 1st local oscillator.

(17) HORIZONTAL SCALE : This nine position push button switch selects sweep widths from 20 Hz/division to 10 MHz/division when used in conjunction with the RANGE (20) switch. Normally it is unnecessary to know the filter bandwidth in use at any given time, as this is automatically selected. Should the bandwidth need to be known, however, it can be read from the table above the push buttons for kHz/division and below for MHz division; the numbers 1, 2 and 3 referring to the NARROW/NORMAL WIDE setting of the FILTER BANDWIDTH push buttons (19).

(18) SWEEP SPEED : On all positions, the sweep speed automatically selected is the fastest sweep possible for negligible loss of amplitude of the spectral lines. However, for tuning in, counter setting or tracking generator use, it is sometimes desired to sweep more quickly even though it causes loss of amplitude and line broadening. To this end, the x5 and x20 buttons are provided which increase sweep speed by approximately the values stated up to 100 ms which is the fastest input data rate permitted by the storage system. The buttons are spring loaded to avoid them being left in the operated, and thus uncalibrated, state.

(19) FILTER BANDWIDTH : In the NORMAL '2' position a filter of approximately 1% of the sweep width (-3 dB point) is selected on all ranges. In the NARROW '1' position a filter 10 times narrower than this is selected (where possible) and in the WIDE '3' position a filter 10 times as wide is selected (where possible). The filter bandwidth selected at any time can be read from the table either side of the HORIZONTAL SCALE push buttons - see (17) above.

(20) RANGE : The kHz/DIV and MHz/DIV buttons are multipliers for the HORIZONTAL SCALE buttons. As the first local oscillator is phase locked in the kHz/DIV position and free running in the MHz/DIV position there can be several hundred kHz shift in centre frequency between the two positions. When changing from kHz/DIV to MHz/DIV this is no problem. When changing from MHz/DIV to kHz/DIV it is suggested that this should only be done using the 0.02 MHz/DIV position (200 kHz sweep) before switching to 10 kHz/DIV position (100 kHz sweep) and using the counter readout to assist if necessary.

(21) VERTICAL SCALE : Thirteen push buttons give input sensitivities in 10 dB steps from +30 dBm to -150 dBm (300 mV r.m.s./division to 300 nV r.m.s./division on LINEAR). The gain and attenuation throughout the receiver is automatically adjusted, depending on the filter in use, such that the i.f. amplifier noise is at the bottom of the 100 dB display consistent with the first signal mixer not operating at an input level greater than -20 dBm. See Fig. 2.2 for signal levels at first signal mixer.

Fig. 2.2 Signal levels at input of first mixer

(22) VERTICAL SCALE : Ten push buttons give an i.f. gain change of 9 dB in 1 dB steps to interpolate between the 10 dB steps of the above scale switch. A yellow ADD light reminds the user to add the requisite number of dB to the table when in any position other than 0 dB. This switch is not calibrated for the VOLTS/DIV position of the VERTICAL SCALE RANGE switch.

(23) GAIN : Permits adjustment of i.f. amplifier gain in the range +7 dB to -3 dB.

(24) INPUT 50 Ω : Maximum continuous input +25 dBm (4 V r.m.s.).

(25) STANDARD 10 MHz OUTPUT : Provides a nominal square wave whose fundamental is at a level of -10 dBm when terminated in 50 Ω.

(26) TRACKING GENERATOR OUTPUT : Provides a sinusoid output at a level of -10 dBm when terminated in 50 Ω. Frequency as indicated on BRIGHT LINE (9) position of counter. The output is switched OFF by the COUNTER ON/OFF switch (10), and adjacent amber light glows.

Rear panel

(27) EXTERNAL STANDARD : Converts an external 1 MHz standard input to a 10 MHz standard which replaces the internal 10 MHz standard.

(28) DETECTED OUTPUT : Provides audio monitoring of a.m. transmissions displayed by the instrument.

(29) SUPPLY VOLTAGE SELECTION : Bar plug selects 100 to 130 V or 200 to 250 V.

(30) SUPPLY socket : 3 pin a.c. supply input connector.

(31) SUPPLY fuse : 2 A for the 200 to 250 V range or 4 A for the 100 to 130 V range.

(32) 3 A fuses : Provide protection for the +5 V d.c. regulated lines.

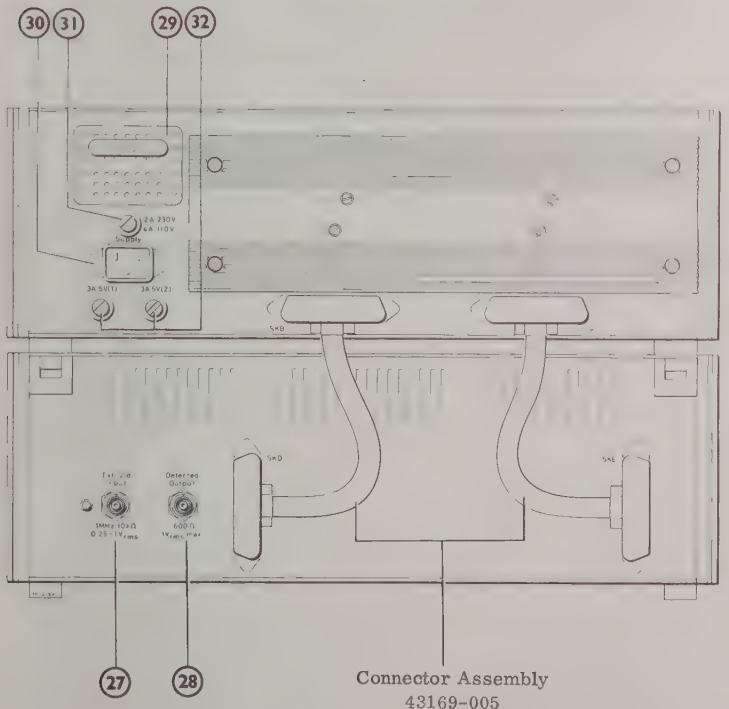

Fig. 2.3 Rear panel controls and connectors

2.3 FIRST TIME OPERATING INSTRUCTIONS

2.3.1 Obtaining a display

Switch on SUPPLY (7). After about half a minute, a display on the c.r.t. should appear. Adjust GRATICULE INTENSITY (6) as required.

Select the following push buttons :

LH	(8)
PAST CENTRE	(9)
AUTO	(11)
HIGH DEFN	(13)/(14)
10 dB/DIV	(15)
10	(17)
NORMAL '2'	(19)
MHz/DIV	(20)
+30	(21)
0	(22)

All other DISPLAY buttons should be in the unpressed state.

Adjust INTENSITY DISPLAY 'A' (6) until a suitable display of noise can be seen. Using the 0-110 MHz and ±1 MHz controls (16) position the d.c. marker onto the left-hand vertical dashed line. Now connect a 50 Ω BNC cable between the STD 10 MHz OUTPUT (25) to the INPUT (24). The screen should display vertical bright lines corresponding to the 10 MHz input signal and its harmonics. These will appear adjacent to every vertical cursor line as 10 MHz/division has been selected.

The height of the 10 MHz component should be 4 major divisions down from the top of the screen, corresponding to -10 dBm.

Press the '5', then '2', then '1' etc. buttons of the HORIZONTAL SCALE (17) and watch the sweep expand the display around the d.c. marker on the left-hand dashed line, adjusting the 0-110 MHz and ±1 MHz controls (16) as necessary. Return the HORIZONTAL SCALE button to 10.

Adjust the VERTICAL SCALE buttons (21) and (22) to become familiar with their operation and then return them to their original positions.

2.3.2 General use

Press CENTRE (8) and adjust 0-110 MHz (16) so that the 10 MHz line is positioned on the centre dashed line. As before, sequentially expand the display using the HORIZONTAL SCALE buttons (17), adjusting the 0-110 MHz,

±1 MHz and ±70 kHz controls (16) as required to keep the display on the centre line. When the '.02' button (17) has been pressed, expansion is at maximum (20 kHz/div) in the unphase-locked mode. Note the counter frequency. Switch to '10' (17) and kHz/DIV (20) and adjust the REFERENCE FREQUENCY control (16) so that the counter returns to its original number: the 10 MHz signal should then appear central again. It will be observed that in this position the 0-110 MHz control phase locks every MHz, the ±1 MHz control phase locks every 100 kHz whilst the last two controls cause continuous variation of tuning. It might be advantageous to press the x5 or x20 SWEEP SPEED buttons (18) whilst carrying out the above adjustment.

If the above operations have been correctly executed the 10 MHz signal should be displayed at the screen centre on a sweep width of 100 kHz (10 kHz/div.). As the sweep rate will now be fairly slow, it is sometimes advantageous to switch in READ IN B/U (13). This adds an artificial persistence to the display, showing clearly on the screen where the data is being renewed. The display shown is using a 500 Hz filter. If NARROW '1' (19) is now pressed, a 50 Hz filter is selected and the sweep will automatically be 100 times slower (press and release START (11) to initiate a fresh complete sweep if the switch-over is made in mid-sweep). Similarly press WIDE '3' to select the 5 kHz filter. Because of the fast sweep in this position, it will probably be desirable to remove the artificial persistence by releasing the READ IN B/U button. Return the FILTER BANDWIDTH button (19) to NORMAL '2' and re-press READ IN B/U button.

2.3.3 Single shot use

Press the SINGLE (11) button. The sweep in progress will be completed and then the bright line electronic cursor will appear on the screen, the position of which may be adjusted by means of BRIGHT LINE POSITION control (12). The counter readout will be showing the centre frequency of the stored single shot. If now, the BRIGHT LINE button (9) is pressed, the counter will read the frequency corresponding to the position of the electronic cursor. Adjust the BRIGHT LINE POSITION control (12) and measure several frequency points to become familiar with the position. Now switch to DIFFERENCE (9). The counter will now read the difference between the past centre frequency of the recorded single sweep and the current frequency of the bright line cursor. Adjust BRIGHT LINE POSITION control (12) until it is superimposed on the dashed centre graticule line. If the counter reading is not zero (±1 count) adjust either the ±70 kHz or ±1 kHz REFERENCE FREQUENCY controls (16) until the zero is established. This operation takes out any drift that may have occurred in the local oscillators since the single sweep was stored. Movement of the electronic cursor will now enable measurements of difference frequency relative to the centre frequency of the stored display to be made.

2.3.4 Manual use

Position the BRIGHT LINE POSITION control (12) so that the bright line cursor is on the left-hand side of the stored display. Now press the MANUAL button (11). As in 2.3.3, if the BRIGHT LINE counter button (9) is pressed, the counter will display the frequency corresponding to the cursor position. Unlike 2.3.3, however, the store is being refreshed at the bright line cursor point. If the cursor is now moved slowly to the right, a new recording of the input signals, as present at that moment, will be recorded on the screen. If the cursor is moved too fast, some of the original data will be left on the screen and the coherent spectral lines will be displayed at too small an amplitude due to the time constant of a 1.5 Hz video filter included for noise averaging in this mode. On some sweeps and filter combinations, the total width of a spectral response might be less than a store line width. In these cases the PEAK MEMORY button (13) should be pressed. This ensures that the store only remembers the largest input to any store location and thus does not miss spectral lines, however fine.

Note The PEAK MEMORY button must be unlatched when it is not being used.

If it is required to selectively edit the stored picture, (for example either side of the 10 MHz carrier), simply press the SINGLE (11) button when it is required to move the cursor without recording new information and MANUAL (11) when it is required to record.

2.3.5 Split store mode

Select the following push buttons:

CENTRE	(8)
PAST CENTRE	(9)
AUTO	(11)
HIGH DEFN	(13)/(14)
10 dB/DIV	(15)
10	(17)
NORMAL '2'	(19)
kHz/DIV	(20)
+30	(21)
0	(22)

All other display buttons should be in the unpressed state. Using the counter as a guide, if required, adjust the REFERENCE FREQUENCY controls (16) to recentre the 10 MHz signal. Use SWEEP SPEED buttons (18) as required.

Now press '2' (17) - the display will run a little faster and be displayed at a horizontal calibration of 2 kHz/division.

Now press STORE 'A' (14) and DISPLAY 'A' (13) buttons. The same picture will be seen but at half the horizontal definition.

Now press SINGLE sweep mode button (11) - the low definition A sweep will be stored.

Now press STORE 'B' (14), DISPLAY 'B' (13) (STORE 'A' button will be released but DISPLAY 'A' button will stay in) and AUTO (11). Now the instrument is recording on the 'B' part of the store whilst simultaneously displaying the previously stored 'A' image superimposed on the current signal. Adjust 'B' DISPLAY INTENSITY (6) as required. Shift the signal using the ·70 kHz REFERENCE FREQUENCY control (16) to become familiar with the two part store. Adjust relative brightnesses of the two displays by means of the 'A' and 'B' DISPLAY controls (6).

Return the store mode buttons to normal by pressing HIGH DEFN (13). (14).

2.3.6 Memory mode

This mode is useful if it is required to imitate the infinite persistence of a storage tube to record the frequency response of say, an oscillator. With the buttons as set, press PEAK MEMORY (13). Now if the ·70 kHz REFERENCE FREQUENCY control (16) is rotated slowly a series of recordings of each successive read-in sweep will be left on the display. The envelope of these points is the frequency response of the system. Normally, of course, the frequency that would be varying is that of the input signal. This position can be used whenever it is desired to store the largest signal ever presented to the analyser. An application of this has been described under Sect. 2.3.4 'Manual use'. To erase the screen of clutter simply release the PEAK MEMORY button (13).

2.3.7 Tracking generator use

All modes so far described also apply to this usage of the instrument. Select the sweep width required, and connect the TRACKING GEN OUTPUT (26) into the INPUT (24) having removed the previous signal lead. Select the VERTICAL SCALE (21) so that 0 dBm is at the top of the display. The signal should be displayed at a constant height of -10 dBm i.e. bright below the -10 dBm level. Store this reference level in STORE 'A' as described in Sect. 2.3.5 and then switch to STORE 'B'. Connect the 50 Ω system under test between the TRACKING GEN OUTPUT (26) and INPUT (24). The display should now show the characterization of the network under test as a frequency response with the frequency response of the spectrum analyser displayed for error correction.

When using the narrow filters, the sweep speed automatically selected may be unnecessarily slow if no comparable fine detail occurs in the network frequency response. The SWEEP SPEED buttons (18) may be used with advantage here if no loss of detail is observed as they are pressed.

2.3.8 Graticule calibration

Over any particular sweep range (before or after a single shot has been stored) the counter can be used to calibrate the frequency graticule to an accuracy of better than ±1% f.s.d. The following example will serve to illustrate the method which can, of course, be applied to any desired range.

Set the controls as follows :

SWEEP MODE (11) to SINGLE
COUNTER FREQUENCY (9) to BRIGHT LINE
HORIZONTAL SCALE (17) to '1'
RANGE (20) to MHz/DIV

Suppose it is desired to leave an absolute calibration at 1 MHz/division around a centre frequency of 25 MHz :

First adjust the bright line electronic cursor to the centre dashed graticule line by means of the BRIGHT LINE POSITION control (12). Now rotate the appropriate REFERENCE FREQUENCY control (16) until the counter reads 25.00 MHz. Rotate the BRIGHT LINE POSITION control counter-clockwise until the counter reads 20.00 MHz. If the left-hand dashed graticule line is not coincident with the cursor line, rotate the HORIZONTAL GRATICULE SHIFT control clockwise away from its uncalibrated position until it is. Finally move the cursor line towards the right-hand side until the counter reads 30.00 MHz. Adjust the right-hand dashed graticule line for coincidence with the cursor using the HORIZONTAL GRATICULE GAIN control. As a check, measure each graticule line on the counter to establish sweep linearity. If an accurate frequency is now applied the absolute accuracy can be checked.

The vertical scale calibration graticule can be shifted by ±1.2 of a major division by means of the VERTICAL SHIFT control (2). This allows a major graticule line to be positioned against any signal of interest so that all other signals can be measured relative to it. The dashed lines on the frequency graticule serve also as group markers enabling any interval to be quickly measured viz. 20, 40, 60, 70, 73 dB instead of 10, 20, 30, 40, 50, 60, 70, 73 dB.

2.3.9 Front panel presets

VERTICAL DISPLAY GAIN (3)

Using the 10 dB/DIV (15) position a WIDE '3' FILTER BANDWIDTH (19) and 10 kHz/division sweep, apply a suitable input signal via a precision attenuator (or use the VERTICAL SCALE (21) push buttons if not available). By adjusting the input in 10 dB steps adjust the VERTICAL DISPLAY GAIN (3) preset for best fit to the top 7 or 8 divisions of the graticule. The STD 10 MHz OUTPUT signal (25) can be used for this purpose.

VERTICAL DISPLAY SHIFT (2)

This control positions the spectral display behind the graticule and should be adjusted so that consistent readings are obtained between the 1 dB/DIV and 10 dB/DIV (15) positions. This is set in conjunction with the SET GAIN preset (23) as follows :

Apply the 10 MHz calibrating signal from OUTPUT (25) to the INPUT (24). With the controls as in 2.3.8, press the 1 dB/DIV (15) button and the -10 VERTICAL SCALE (21) button. Ensure the 1 dB interval buttons (22) are at '0'. Press PAST CENTRE (9) and HIGH DEFN (13), (14) and tune to 10 MHz.

Adjust the SET GAIN (23) preset until the top of the response is on the line at the top of the display. Now switch to 10 dB/DIV (15), '0' VERTICAL SCALE (21) and set the VERTICAL SHIFT preset (2) to bring the top of the response to the first major division from the top of the screen (-10 dBm). Repeat this adjustment as necessary.

HORIZONTAL GRATICULE SHIFT (4) AND GAIN (5)

Select the following push buttons:

CENTRE	(8)
PAST CENTRE	(9)
AUTO	(11)
10	(17)
MHz/DIV	(20)
HIGH DEFN	(13)/(14)
10 dB/DIV	(15)
+30	(21)
NORMAL '2'	(19)

Set the INTENSITY 'A' control (6) fully counter-clockwise to avoid a cluttered display.

Set the counter to read 50.0 MHz by means of the 0-110 MHz and ·1 MHz (16) controls. Switch to SINGLE (11) and BRIGHT LINE (9). Press LH (8) and adjust the BRIGHT LINE POSITION control (12) so that the counter again reads 50.0 MHz.

Adjust the preset SHIFT control (4) (with the main control in its calibrated position) so that the left-hand dashed graticule line coincides with the electronic cursor.

Now press CENTRE (8) button and readjust the BRIGHT LINE POSITION control (12) so that the counter reads 50.0 MHz again. Adjust the preset GAIN control (5) (with the main control in its calibrated position) so that the centre dashed line coincides with the electronic cursor.

2.3.10 Ancillary facilities

DETECTED OUTPUT (at rear of instrument)

Select the following push buttons:

CENTRE	(8)
PAST CENTRE	(9)
AUTO	(11)
HIGH DEFN	(13)/(14)
10 dB/DIV	(15)
10	(17)
NORMAL '2'	(19)
MHz/DIV	(20)
0	(21)
0	(22)

All other DISPLAY buttons should be in the unpressed state.

Apply a signal, amplitude modulated at 1 to 10 kHz, to the INPUT (24). Adjust the REFERENCE FREQUENCY controls (16) to centre the signal. Expand the frequency scale using the HORIZONTAL SCALE (17) buttons, recentring the display as necessary, until a dispersion of 0.02 MHz/div. is reached. Select a NARROW (19) filter so that the carrier and sidebands are separately resolvable. Adjust the VERTICAL SCALE (21), (22) buttons until the carrier is 40 dB down from the top of the display. Press MANUAL (11) and WIDE (19) filter, and tune using the BRIGHT LINE POSITION control (12). The brightened-up portion of the electronic cursor should be adjusted to maximum (-34 to -40 dB from the top of the display depending on the modulation depth). The detected output socket at the rear of the instrument will now carry the demodulated signal at 0 dB into 600 Ω for 100% modulation or proportionately less for smaller modulation depths.

Experiment with different modulation frequencies and filter bandwidths using the kHz DIV (20), HORIZONTAL SCALE (17), REFERENCE FREQUENCY (16) and FILTER BANDWIDTH (19) controls as appropriate. At all times keep the displayed signal at approximately 10 dB down from the top of the display (10 dB div.) or at the top of the display (1 dB div.) for maximum undistorted detected output.

FM signals may be detected for identification purposes by tuning the signal down the skirt of the filter appropriate to the deviation of the signal.

EXTERNAL STANDARD INPUT

To use this facility, apply a 1 MHz ±0.1 Hz signal, at between 0.25 V and 1 V r.m.s., to the appropriate rear BNC socket. A green light will glow to indicate that the external signal has replaced the internal standard.

To check the correct functioning of this facility, connect the STANDARD 10 MHz OUTPUT (25) to one channel of a dual trace oscilloscope, and the external standard signal to the other channel. If the oscilloscope is triggered by the 1 MHz external standard, the internal 10 MHz signal will drift across the oscilloscope screen due to the frequency error between the two standards. If the external signal is also fed to the external standard input socket (rear panel) the drift of the 10 MHz signal will cease showing that the 10 MHz standard is now in phase with the external 1 MHz standard.

2.4 USEFUL PROCEDURES

2.4.1 Sweep width

If the frequency of the input signal is not accurately known, the method of starting with a wide sweep and successively narrowing the sweep around the signal must be used. However, if the signal frequency is known, for example within 1 kHz, the following method enables a narrow sweep of the signal to be directly obtained.

Select push buttons and set controls as follows:

CENTRE	(8)	
BRIGHT LINE	(9)	
MAN	(11)	
10 dB/DIV	(15)	
HIGH DEFN	(13)/(14)	
BRIGHT LINE POSITION	(12)	to position electronic cursor on centre dashed line
0.2	(17)	
kHz/DIV	(20)	
WIDE	(19)	
REFERENCE FREQUENCY	(16)	to approximately centre the ±70 kHz and ±1 kHz controls

Using REFERENCE FREQUENCY (16) adjust the 0-110 MHz control and obtain a counter readout to the nearest MHz of the input signal. Set the ±1 MHz control to the nearest 100 kHz increment, and then tune the ±70 kHz and ±1 kHz controls to the exact frequency required.

Select the NORMAL (19) and AUTO (11) buttons. A sweep covering ±1 kHz around the input signal, together with the input signal, should be displayed. The VERTICAL SCALE (21) buttons may now be adjusted as required.

By re-centring the input signal with the ±70 kHz and ±1 kHz controls (16), the frequency scan may be further narrowed to 20 Hz/division using the SWEEP SPEED (18) buttons or the WIDE (19) button to speed the process.

Note If during this procedure the signal trace disappears, check the counter with MAN (11) and WIDE (19) buttons. If the counter is exactly 1 MHz or 100 kHz in error, the phase locking system will have jumped to an adjacent lock position, and the REFERENCE FREQUENCY controls (16) should be adjusted. The 0-110 MHz control will correct a 1 MHz error, and the ±1 MHz control corrects a 100 kHz error.

2.4.2 Spectral line frequency

To measure the frequency of any of the displayed spectral lines accurately, press SINGLE (11) button and wait for completion of the scan. Then superimpose the electronic cursor onto the required spectral line using the BRIGHT LINE POSITION control (12), and read the counter frequency. For the greatest possible accuracy, press MAN (11) button and adjust the electronic cursor to give a peak value on the required response, and read the counter while maintaining this condition.

2.4.3 Two-tone testing

When using two equal-level tones for intermodulation testing it is important to ensure that the level of each tone is no higher than -40 dBm at the input of the first mixer. In practice this means restricting the level of the displayed tones to -20 dB relative to the top of the screen except when using the narrowest (5 Hz) filter bandwidth and/or the most sensitive (-50 dBm) vertical scale, in which case the tones can be increased to the top of the screen.

Even with a tone level of -20 dB an adequate dynamic range is available for most intermodulation distortion measurements. However, tone levels intermediate between -20 dB and the top of the screen may be used at various combinations of filter bandwidth and vertical sensitivity - see Fig. 2.2 and the calibration table on Fig. 7.7.

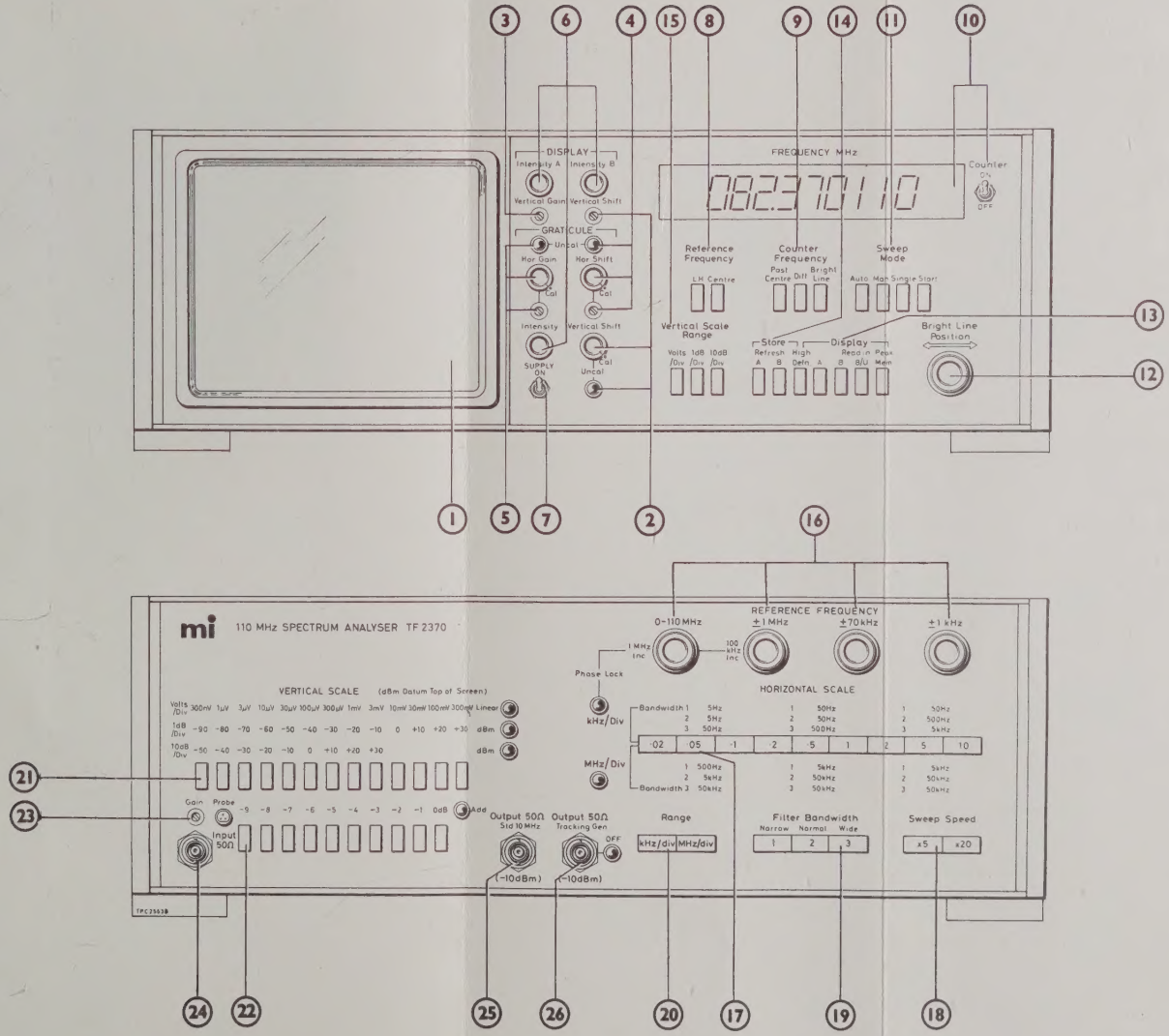

Fig. 2.1 Front panel controls and connectors

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